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ABSTRACT

Educators throughout the northwest are striving to ensure that all students have opportunities to learn rigorous mathematics and science. State standards that define high quality, challenging, mathematics and science education programs for all students are in place. The science and mathematics education community is engaged in the task of translating those standards into effective teaching and learning practices. The complexities of implementing a standards-based system are explored and analyzed in a variety of educational research projects and settings. An important insight that emerges from this research is the impact of a culture that nurtures and supports continuous improvement for students and teachers alike. Schools and classrooms where this culture is the norm are often designated as learning communities. This document offers readers a variety of strategies and resources for creating such an organization. Reasons why the classroom environment is important, changing the classroom environment, three models of designing a learning community, and establishing classroom norms are also discussed. (Contains 66 references.) (ASK)

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Mathematics and Science Classrooms: Building a Community of Learners

It's Just Good Teaching

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Mathematics and Science Classrooms: Building a Community of Learners

It's Just Good Teaching

By Jennifer Stepanek
Mathematics and Science Education Center

June 2000

Northwest Regional Educational Laboratory

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Preface

EDUCATORS THROUGHOUT THE NORTHWEST ARE STRIVING to meet ensure that all students have opportunities to learn rigorous mathematics and science. State standards that define high quality, challenging mathematics and science education programs for all students are in place. Now, the science and mathematics education community is engaged in the task of translating those standards into effective teaching and learning practices. The complexities of implementing a standards-based system are being explored and analyzed in a variety of educational research projects and settings. An important insight emerging from this research is the impact of a culture that nurtures and supports continuous improvement for students and teachers alike. Schools and classrooms where this culture is the norm are often designated as learning communities.

Mathematics and Science Classrooms: Building a Community of Learners offers readers a variety of strategies and resources for creating such an organization. The supportive classroom climate characteristic of a learning community and described in this publication does not mean lowering expectations or losing academic rigor, but quite the opposite. In order to accomplish the goal of meeting challenging state standards, classrooms must become places where students are not ashamed of making mistakes. Instead, errors and misconceptions are recognized as an important and often necessary aspect of achieving deep conceptual understanding.

We believe creating classrooms that embrace the characteristics of a community of learners is essential for rigorous mathematics and science teaching and learning. We hope readers will find this publication useful in their efforts to provide all students with high-quality mathematics and science learning experiences.

Kit Peixotto
Director
Mathematics and Science Education Center

Introduction

THE PUSH TO INTENSIFY ACCOUNTABILITY FOR TEACHERS and students is widespread throughout the Northwest and the rest of the United States. Teachers often believe that paying attention to the classroom environment—things like well-being, relationships, and positive emotions—must be put aside in favor of the demands of rigorous learning and tight schedules. However, relationships and the classroom climate are the foundations of teaching and learning. Student perceptions of the classroom environment—their feelings of acceptance, care, and participation—are directly related to their motivation to learn and to academic achievement.

There are different conceptions of what a positive classroom environment could look like. Is the ideal classroom one in which students are quiet and remain in their seats, following directions or listening to the teacher talk? Or does it look more like a gathering of children who are actively engaged in learning, talking together, *doing* mathematics or science, and perhaps even having fun?

The latter example is untraditional, but it is the type of classroom advocated by mathematics and science standards, as well as current learning theories and cognitive research. Teaching for understanding—the primary goal of mathematics and science education reform—requires that students are actively engaged in the classroom, are willing and able to communicate their ideas, and are able to learn from each other. This publication provides teachers with strategies to create a sense of community among their students and the necessary climate for learning.

Why is the Classroom Environment Important?

THE CLASSROOM ENVIRONMENT IS MORE THAN JUST THE physical space; it is the entire setting for learning. It encompasses the relationships between and among students and teachers, as well as the expectations and norms for learning and behavior. Positive classroom environments are associated with a range of important outcomes for students.

Achievement. It is difficult to establish a direct causal link between positive classroom environments and academic achievement because of the many variables involved. However, there is a proven relationship between these two aspects of education, and science is the leading field for research on classroom environment. Numerous studies have clearly demonstrated that the learning environment has a significant impact on student achievement, as well as emotional and social outcomes at all grade levels (Fraser, 1994; McRobbie & Fraser, 1993). In fact, positive classroom environments have been shown to improve the achievement of low-performing students (Pierce, 1994). Such findings suggest that deficient skills are not the sole reason for students' low performance on tests.

Another interesting outcome of the research is that student achievement is higher when the actual classroom environment is consistent with students' preferred classroom environment (Fraser, Giddings, & McRobbie, 1995). Of course, this does not mean that teachers should attempt the impossible task of tailoring the classroom to all students' individual preferences. But perhaps contrary to conventional wisdom, teachers do not have to choose between high student achievement and creating a congenial classroom (Fraser, 1994).

Motivation. A widely accepted theory about the relationship between classroom environment and academic achievement is that the effect is mediated through student motivation. Research shows that motivation is highly related to both academic achievement and the learning environment (Cheng, 1994; Uguroglu & Walberg, 1986).

Motivation is related to later mathematics achievement and attitude (Reynolds & Walberg, 1992). Currently, there is a trend of decreasing

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achievement in mathematics that is linked to a decline in student interest and motivation in mathematics (Schiefele & Csikszentmihalyi, 1995). There is a general decline in students' achievement motivation in middle school, with the greatest declines in intrinsic motivation occurring in science (Gottfried, 1985). The characteristics of the learning environment may account for this decline, including the deterioration of relationships between teachers and students and a decrease in students' sense of choice and control (Eccles et al., 1993).

Cognitive research. New understandings about the effect of emotions on brain processes have important implications for the learning environment. Cognitive scientists have found that positive emotions and relationships enhance learning and memory, while negative emotions have the opposite effect. Ignoring the social and emotional aspects of the classroom lowers students' attention levels and hinders their ability to make meaning of what they are learning (Jensen, 1998).

Student perceptions. Students' beliefs about the learning environment determine whether or not the classroom climate has a positive effect. Yet students' perceptions and reactions to the learning environment may not match the teacher's intentions. Changing the classroom environment to improve students' perceptions improves achievement as well as outcomes such as interest and motivation (Waxman & Huang, 1996). For example, students' positive perceptions of the classroom environment contribute to developing a favorable attitude toward mathematics (Reynolds & Walberg, 1992).

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Changing the Classroom Environment

IT IS CLEAR THAT THE CLASSROOM ENVIRONMENT PLAYS AN important role in learning. Research about the characteristics of effective learning environments suggests that changes need to take place in science and mathematics classrooms. Traditional ideas of teacher and student roles and tightly controlled classroom management, as well as insufficient attention to emotions and relationships, do not facilitate meaningful learning. There are three primary reasons that changes need to be made: to make the classroom environment more congenial for students, to support how students really learn, and to foster standards-based teaching and learning.

Creating a supportive and inspiring classroom. Research on classroom environment has identified a number of qualities associated with positive learning outcomes. The following are the key areas for improving the learning environment in mathematics and science classrooms:

- Supportive relationships among teachers and students
- Student participation in creating classroom norms, making decisions, and setting goals
- Clear expectations and responsibilities
- Opportunities for collaboration
- Adequate time for completing tasks and for discussions
- Opportunities to work on open-ended tasks
- Interesting and meaningful activities

(Henningsen & Stein, 1997; Huffman, Lawrenz, & Minger, 1997; McLeod, 1992; McRobbie & Fraser, 1993)

In mathematics and science, many of the classroom factors listed above also influence students' positive attitudes. For example, students with favorable attitudes toward science feel that they are involved in class and perceive a great deal of both academic and personal support from the teacher. These students also understand the classroom expectations and rules and report friendly and strong relationships with their classmates (Fouts & Myers, 1992).

Helping students construct their own knowledge. Beliefs and theories about how children learn are also changing ideas about what schools and classrooms should be like. Many educators believe that people do not learn by having information transmitted to them, but by creating their own knowledge. While some people are able to do this by listening to a lecture or reading a textbook, many others must have direct experiences and opportunities to talk about their ideas in order to understand what they learn. A constructivist approach is based on the premise that learning is most effective when "the learner is actively engaged in creating his or her own knowledge and understanding by connecting what is being learned with prior knowledge and experiences" (McCombs & Whisler, 1997).

"CONSTRUCTIVIST TEACHERS ASK RATHER THAN TELL, THEY MODEL RATHER THAN EXPLAIN, AND THEY WORK AS HARD AS POSSIBLE TO GET OUT OF THE LIMELIGHT SO THAT THEIR STUDENTS MAY SHINE."

(Marlowe & Page, 1998)

Constructing knowledge and understanding is a social, interactive process (Driver, Asoko, Leach, Mortiner, & Scott, 1994). Students learn from each other by sharing their ideas and points of view, asking questions, and building on their shared methods and ideas. The processes of communicating about their thinking and of working to create shared ways of thinking are also essential for learning (Bruner, 1996).

The learning environment is a key component in guiding students toward an interactive and constructivist approach to learning. Some features that help to create such an environment include small group discussions, student-generated research topics and investigations, active involvement, and evaluations that emphasize reasoning, evidence, and personal interpretations rather than only correct results (Roth & Roychoudhury, 1994).

Meeting high standards. Both the *National Science Education Standards* (National Research Council [NRC], 1996) and the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics [NCTM], 1991) outline the classroom environment that is necessary to help students learn and understand challenging and important mathematics and science. Both documents emphasize students' active participation in the classroom, opportunities for cooperative learning, and creating and maintaining a safe environment.

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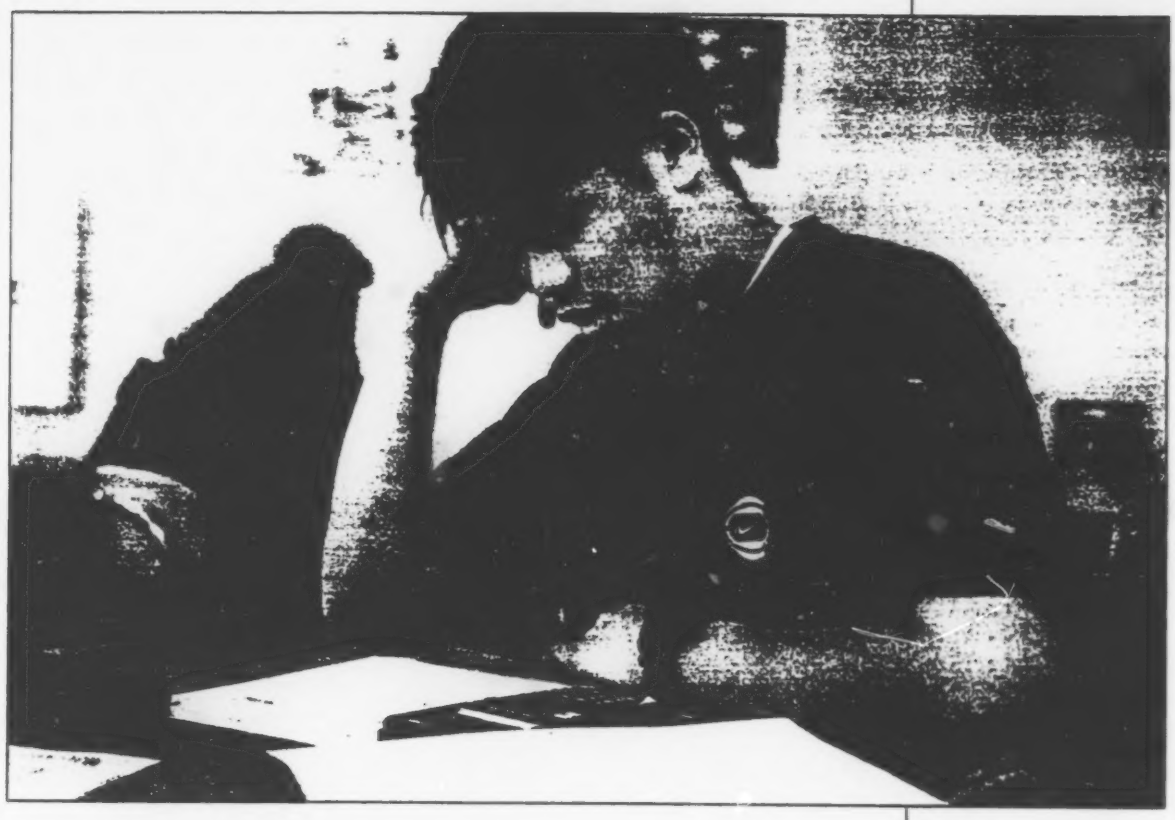

The influence of the classroom environment on students' motivation and enthusiasm is especially important as students are asked to develop deep understanding of challenging mathematics and science topics. One of the goals of the mathematics and science standards is to encourage students to have favorable attitudes toward mathematics and science, in part because of the effects on students' learning. Positive emotions and intrinsic motivation are essential for success in problem solving, creativity, and conceptual understanding (Schiefele & Csikszentmihalyi, 1995).

What is a Learning Community?

LEARNING MATHEMATICS AND SCIENCE IS NOT AN ISOLATED or passive activity. It is above all a process of making sense and establishing meaning, both individually and collectively. The mathematics and science standards promote the idea of creating a learning community with a shared purpose of making sense of science and mathematics. The concept of community is vital to learning because it facilitates social interaction, active participation, and mutual support.

The science standards suggest that the characteristics of a classroom community include: respect for diverse ideas, skills, and experiences; student responsibility for their own and each other's learning; and collaboration (NRC, 1996). In such a community, the teacher helps students to learn with and from each other. The structure of the class varies, with opportunities for students to work independently, in an assortment of teams and small groups, and as a whole class. In addition, the teacher consistently demonstrates respect for students' ideas and ways of thinking, encouraging them to raise questions, make conjectures, and validate their solutions (NCTM, 1991).

"A COMMUNITY APPROACH ENHANCES LEARNING: IT HELPS TO ADVANCE UNDERSTANDING, EXPAND STUDENTS' CAPABILITIES FOR INVESTIGATION, ENRICH THE QUESTIONS THAT GUIDE INQUIRY, AND AID STUDENTS IN GIVING MEANING TO EXPERIENCES."

(NRC, 1996)

There is a danger that the concept of a learning community will be misinterpreted and become counterproductive, if not harmful. This is especially true when the community is used to manipulate students toward conformity. A community of learners is not free of differences. Rather, the classroom becomes a place where students can be themselves and where their ways of knowing, thinking, and expressing themselves are valued. Students' cultural identities—which encompass race, class, religion, gender, and family—are accepted and celebrated (Wlodkowski & Ginsberg, 1995).

Thinking about the school or classroom as a community is not a new idea. John Dewey is often credited with creating the idea of schools and classrooms as communities, and his approach is helpful in understanding what community means in the classroom. For Dewey, community

is not just a name for a collection of individuals or an ideal of harmony and collaboration. It is a *process* of people living, working, and especially learning together (Dewey, 1916).

Dewey believed that the processes of community, democracy, and education are intertwined and essential to each other—in fact, community is inherently educational. The processes of community and democracy are all about learning: asking questions, listening to other viewpoints, comparing ideas, and imagining alternatives. "One cannot share in intercourse with others without learning—without getting a broader point of view and perceiving things of which one would otherwise be ignorant" (Dewey, 1916).

Designing a Learning Community: Three Models

THERE ARE THREE CLASSROOM MODELS THAT MAY BE HELPFUL in thinking about and creating a community of learners. There are many similarities between the three approaches, and they all help to create an environment necessary for learning. While some teachers may be drawn to a particular model, others may wish to combine ideas from all three.

The democratic classroom. The central purposes of the democratic classroom are sharing ideas, using critical reflection and analysis, and promoting the common good (Beane & Apple, 1995). A democratic classroom is not one in which students vote on all organizational and instructional decisions. It does not mean that students do only what they are inclined to do. Rather, it is a process of giving students a share of the authority in the classroom, but not deferring to them.

In a democratic classroom, students have opportunities to actively participate, which also makes it possible for them to persevere in challenging mathematics and science. Participating in a classroom or school grounded in democratic principles helps to prepare students to use their mathematical and scientific knowledge as informed citizens. Finally, the democratic classroom promotes supportive relationships and a safe environment by focusing on concern for valuing and respecting all members and the general well-being of the classroom community.

The following are some of the principles upon which the democratic classroom is built:

- Students participate in decisionmaking
- Teachers and students think of themselves as members of a community of learning
- Collaborative planning with students helps to bring their interests and concerns into what they are learning
- Diversity is valued for enriching experiences and viewpoints
- Teachers and students have a sense of shared purpose in learning

- Collaboration and helping one another are emphasized rather than competition

(Beane & Apple, 1995)

The caring classroom. Relationships between teachers and students are the central focus of the caring classroom. There are a range of positive outcomes associated with caring relationships in school, including higher achievement, stronger motivation to learn, greater interest in school, and fewer behavior problems (Lewis, Schaps, & Watson, 1996). In a caring classroom, all students know that they are important and have something to contribute.

There are two ways that the concept of caring can be applied to learning. First, there is the sense that students have of being cared for and of caring for each other. This is important in establishing the trust, safety, and collaboration necessary for the pursuit of challenging mathematics and science (Noddings, 1993). Caring also involves the relationships that students have with the disciplines of mathematics and science. When a student cares about the content and ideas that she is learning, she makes an emotional investment that brings energy and excitement to the pursuit of knowledge.

Some of the characteristics of the caring classroom include:

- Teachers establish warm and supportive relationships with and among their students
- Teachers build on students' inherent interests in learning and making sense of the world
- The curriculum is challenging, important, and thematic; it is focused on long-term learning goals rather than "coverage"
- Teachers support students' intrinsic motivation rather than using rewards and punishments to manufacture compliance
- Students help establish the norms for classroom behavior in the interest of their mutual well-being

(Lewis, Schaps, & Watson, 1996)

The ecological classroom. All classrooms are complex systems, with dynamic interactions and unpredictable events (Patterson, 1996). Looking at the classroom as an ecological system is another way of creating a learning community. In an ecosystem—such as a wetlands or a desert—all aspects of life are interrelated and depend on each other's well-being. Teaching and learning are also built on relationships and interdependence (Hassard, 1990). Teachers taking an ecological view know that the relationships

that students have with each other and with the teacher are essential to learning rather than a separate concern.

Adopting an ecological perspective encourages teachers to take on a more interactive or responsive role in the classroom and become a part of the system. Rather than trying to control the classroom environment, the teacher uses a more cooperative approach. The concept of stewardship– the careful and responsible management of something entrusted to one's care– helps to illustrate the teacher's role in the ecological classroom.

Diversity of life in an ecosystem is necessary for survival. Life in the classroom is also enriched by different experiences and cultures that teachers and students bring. Learning is not an individualistic activity but a collective effort, and everyone is able to learn from each other (Hassard, 1990).

The ecological classroom will include the following elements:

- Teachers remain attuned to the connection between classroom climate and learning
- Teaching and learning are reciprocal processes
- Interdisciplinary connections are created whenever possible
- Attitudes and perceptions are incorporated as elements of the learning process
- Teachers are sensitive to the influence of students' lives outside of the classroom

(Hassard, 1990)

Establishing Classroom Norms

IN ORDER TO BEGIN THE PROCESS OF WORKING AS A COMMUnity, teachers will need to develop a vision of the classroom environment with their students from the first day of class. The whole group will discuss, negotiate, and adopt this vision in order for all students to share and value it. Rules of conduct and expectations will evolve from this collective vision (NRC, 1996).

In a learning community, students help set standards for their behavior and create the norms, or shared expectations, necessary for learning. While this is primarily a classroom management issue, it does involve important implications for learning. Students gain a sense of ownership in the classroom and over the learning process, paving the way for them to take on very active roles. The process of establishing norms also guides students toward thinking about how they learn.

"IT IS THROUGH THE GIVE AND TAKE OF SHARED QUESTIONS, IDEAS, AND FEELINGS THAT COMMUNITY BEGINS."

(Lappan & Ferrini-Mundy, 1993)

Roth (1995) studied the elements of a classroom as a science community centered on sharing knowledge. Students are actively involved in making decisions, planning and organizing activities, and establishing classroom norms. This makes it possible for students to share ideas and build on the thinking of others, even when they initially feel individual ownership of materials and ideas (Roth, 1995). Students who are accustomed to a competitive environment in the classroom will need time to adjust to a community approach.

High school science teachers Smithenry and Bolos (1997) provide a helpful model for establishing a sense of community among students. They suggest that teachers begin the school year by asking students for their ideas of what scientists do, what tools and materials they use, and the environment in which they work. This leads into a discussion about the fact that scientists rarely work in isolation, but rather collaborate with their colleagues (Smithenry & Bolos, 1997).

The next phase concentrates on finding out when students have acted as scientists in the past. They may need examples to get the discussion off

the ground—activities such as observing, asking questions, or speculating about phenomena. This helps students to think of themselves as people who can do science. Using all of this information, the teacher guides students in laying out what the classroom should be like and how they can establish a learning community (Smithenry & Bolos, 1997).

Another approach to creating classroom norms is to begin by outlining students' responsibilities as members of a learning community. For example, all students must contribute to everyone's efforts to learn, share and explain their methods and ideas, and make an effort to understand and build on other students' ideas (Palincsar, Anderson, & David, 1993). The students also discuss and establish the practices that enable them to fulfill their responsibilities, which might include sharing resources, taking turns, asking questions, listening, and acknowledging good ideas (Palincsar, Anderson, & David, 1993). From these practices, the teacher and students can generate classroom rules or a code of behavior. It is worth noting that students' sense of responsibility to and for each other is a common characteristic of mathematics and science classrooms in Japan, and is associated with creating a climate of high achievement (Schmidt et al., 1996).

The idea of giving students a voice in establishing classroom rules is not a new idea, but it goes against many traditional means of establishing order and discipline in the classroom. Teachers in all grade levels who use and adapt this approach often find that students have much greater respect for rules that they help to create (McCombs & Whisler, 1997; Ozvold, 1996; Parker, 1993; Ridley & Walther, 1995; Tsurda, 1994).

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Developing Relationships that Facilitate Learning

RELATIONSHIPS ARE THE HEART OF A COMMUNITY OF LEARNers—without supportive and caring relationships in the classroom, efforts to build community will not succeed. Learning requires emotional safety, caring, and respect, especially when students must be able to ask and answer questions, to explain their ideas, to take intellectual risks, and to give and receive help. Listening, helping each other, and asking questions become essential, as opposed to silence, speed, and neatness (Lappan & Ferrini-Mundy, 1993).

Caring. In a caring community, all members are important, and everyone has significant contributions to make both to learning and to the general well-being (Elias et al., 1997). Students report that a sense of being known and of being friendly with other students leads to a more congenial learning environment and increased motivation to learn and participate in school (Waxman & Huang, 1996).

Teachers have opportunities to establish caring in all of their interactions with students. Everyone is treated with respect and acceptance, which is not based on prior academic performance or special abilities. Teachers enable students to be personally involved in their classrooms, to bring themselves to learning by emphasizing and modeling acceptance.

Getting to know the student is also important in establishing caring relationships. The knowledge that teachers gain about their students—their interests, experiences, values, personalities—serves many purposes in addition to establishing a favorable climate. It is essential information for planning activities and discussions (Dodd, 1995).

Teachers will find that they must allow students to know them as well, by talking about their lives outside the classroom and by sharing their own interests and past experiences. Students themselves report the significance of personal relationships with their teachers. When students understand that they are important to their teachers, they are more motivated to learn and have an increased sense of responsibility for such things as being prepared and on time, or applying their efforts to learning (Bosworth, 1995).

Many strategies for promoting caring are simple, but they are also powerful when consistently enacted. For example, teachers can be sure to greet students and make contact with them both through eye contact and moving around in the classroom (McCombs & Whisler, 1997). Teachers can also look for ways to give students personal attention by taking an interest in students' lives, making time for informal talk, and writing students personal notes of encouragement (Ridley & Walther, 1995).

In middle schools and high schools, teachers often give up their roles as nurturers and caregivers. The classroom is viewed as a place where teachers and students must get down to the serious business of learning mathematics and science, preparing for future education and careers. The traditional structure of secondary schools also hinders caring relationships, because teachers and students spend so little time together. As a result, students often miss the sense of being cared for that they had as younger children. Students who are alienated from school and learning consistently say that they lack personal and caring relationships with their teachers.

Safety. Learning can be an uncomfortable and even a painful process as students deal with the disequilibrium of not knowing. Teachers who are learning new practices may understand this better than anyone. Students are afraid to make mistakes or risk looking foolish when emphasis is placed on getting the right answer and getting it quickly.

"LIFE IN A LEARNING COMMUNITY IS HELPED ALONG BY THE INTERESTS, IDEAS, AND SUPPORT OF OTHERS. SOCIAL LIFE IS NOT SNUFFED OUT ... CARING AND INTEREST OF OTHERS BREATHES PURPOSE AND LIFE INTO LEARNING."

(Peterson, 1992)

One of the reasons that safety is so important in the classroom is the effect of threat on the brain, and subsequently learning. In fact, removing threats is one of the most important parts of establishing effective learning environments (Jensen, 1998). When students feel fearful or anxious—whether the threats are real or imagined, physical or emotional—they go into "survival" mode. Their brains release chemicals that hinder the transmission of information and their attention to learning decreases (Elias et al., 1997).

On the other end of the spectrum, positive emotions release neurotransmitters that enhance learning and memory (Jensen, 1998). The emotional centers of the brain have strong connections to the prefrontal lobes, which are the location of working memory (O'Neil, 1996). And because emotions drive attention, positive feelings are a source of energy for learning (Sylwester, 1994).

A safe environment becomes especially important when students are working on challenging mathematics and science and are expected to understand what they are learning. Open-ended problem solving and inquiry involve complex tasks that are more ambiguous and often mean more risks for students than traditional activities (Henningsen & Stein, 1997).

Teachers can support students by creating a climate in which risk taking is valued and supported. Equally important is emphasizing that mistakes are an important part of learning. Taking the emphasis off getting the right answer or earning points and grades helps to establish this approach. Students are more willing to risk making mistakes when they have opportunities to make corrections or revise their answers. Teachers can also discuss the importance of risk taking for advancing mathematical and scientific knowledge: Making and testing hypotheses and finding mistakes are important steps in learning and in the scientific process.

Teachers also establish a safe learning environment when they model doubt or hesitation for their students. Students learn how to treat their own mistakes or uncertainties from watching their teachers. For example, teachers can make a point of thinking out loud and admitting when they make mistakes. It will be especially helpful to be explicit about the fact that it is difficult to admit mistakes and that it is normal to feel uncomfortable. Students can then talk about their own feelings, as well as strategies to help each other. Teachers also encourage students to feel safe when they talk about learning risks that they have taken and when they show that it is okay to not know the answer.

Emotional safety is also important in a learning community because students are expected to share their ideas with the whole class. Students are required to explain their reasoning or findings and to answer questions from the teacher and their classmates (Carpenter & Lehrer, 1999; Hiebert et al., 1997). Students may become anxious when teachers probe their thinking rather than proclaiming their answer correct or incorrect.

Creating a safe classroom environment does not mean that students' errors go unchecked or that incorrect ideas are accepted as valid (NCTM, 1991). A safe classroom will be one in which students are not ashamed or afraid of making mistakes, because errors and misunderstandings are addressed in a way that allows students to learn from them (Hiebert et al, 1997). In addition, a sense of safety does not come from lack of disagreement, but from the freedom to disagree.

Teachers can check for understanding without demeaning students or making them feel invalidated or judged. Establishing a norm of asking for explanations and justifications prevents students from feeling threatened or defensive. Students become accustomed to explaining their ideas and solutions, and the teacher's questions are no longer a cue that a given answer is incorrect (Yackel & Cobb, 1996).

When teachers are familiar with common misconceptions in mathematics and science, they can provide reassurance to students (McCombs & Whisler, 1997). They might say something like, "Many people make that mistake when they are learning fractions," "I am glad that you said that, because it is a common misunderstanding," or "That's a good beginning. Let's take it further and explore your reasoning." In science, common mis-

conceptions are often the starting point for inquiry activities. Students have opportunities to test their own theories by collecting, analyzing, and discussing data. For example, students often believe that friction only occurs between solids and that it causes electricity (Stead & Osborne, 1980, cited in Driver, Squires, Rushworth, & Wood-Robinson, 1994). After first asking students for their ideas about friction, the teacher might work with students to identify an activity in which they can test their personal theories.

Respect. In a learning community focused on sharing ideas and building knowledge, respect is a key feature. Teachers model and communicate respect for students and their ideas in what they say and do (NRC, 1996). One way to do this is by following a student's question or idea rather than sticking to the planned lesson. Even when it is not feasible to pursue students' suggestions, teachers can convey the fact that the ideas are valuable, but that time and resources do not permit the class to pursue the topic.

Demonstrating respect for students' ideas is also a means for teachers to better know their students and their understandings, which is important information for guiding instruction. A teacher conveys respect when he probes students' thinking while at the same time clearly showing that he is interested in what students have to say. Students must believe that the teacher is making an effort to understand their approaches and ideas, rather than looking for a specific answer or for their mistakes. In addition, all interactions must be free of ridicule, quick dismissal, or humiliation (NCTM, 1991).

It may be helpful to keep in mind that when students share their thinking and their processes, they are subjected to the judgment of the teacher and their peers. This creates the potential that students' differences will be placed in the spotlight. The learning community must come to expect differences and appreciate the learning that comes from divergent ideas (Secada & Berman, 1999). To prevent feelings of defensiveness or fear, students should come to understand that asking questions about their methods and their reasoning is a means of showing appreciation (Hiebert et al, 1997). More students will be encouraged to share their ideas when they know that their contributions will be treated with respect.

Student perceptions. In order to create and maintain the learning community, teachers need to take students' beliefs about the learning environment into account. All teachers need to determine if students' perceptions of the classroom are consistent with their own perceptions and intentions (Waxman & Huang, 1996).

The ideal will be to establish a general openness about classroom norms, so that students are encouraged to ask questions and provide feedback. Teachers can also make an effort to interact with students and collect feedback informally, or distribute questionnaires asking students for their thoughts on how to improve the classroom climate (Fraser & Fisher,

1986). The teacher might also ask students to talk about these questions in small groups or write brief reflections about their feelings. (Some sample questions are listed in the sidebar on this page.)

Student perceptions are also important as teachers shift toward a more constructivist approach to learning. Students must also make this shift in their beliefs about the learning process, the role that they play in that process, and the role of the teacher (Roth & Roychoudhury, 1994). Students often expect the teacher to act as the source of knowledge and validation, and they will need time to adjust to a different approach. It may be helpful to talk with students about the goal of helping them to be independent learners and the difference between knowing mathematics and science with understanding versus memorization (Roth & Roychoudhury, 1994).

Questions for Students

- What do you like about this class? What don't you like?
- Do you feel it is okay to ask questions and share your ideas? Why?
- Do you get along well with other students in this class?
- What do you enjoy about working with other students?
- Are there things that you do not enjoy?
- What helps you to participate in class discussions? What makes it hard for you to participate?
- What can the teacher and other students do to help you learn?
- What can you do to help others learn?

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A Classroom Community Built on Respect

GINGER REDLINGER'S STUDENT-CENTERED APPROACH TO teaching is apparent even from the first look into her sixth-grade classroom at Inza R. Wood Middle School in Wilsonville, Oregon. While Redlinger's enthusiasm for the Star Wars movies has a decided influence on the décor, it is also clearly the students' classroom. The walls tell a story about what the students have learned – currently, walls are covered with posters that students have made to present data from a survey of their classmates. There are also signs and posters that tell a story about the expectations and the atmosphere that Redlinger creates, as well as the relationships that she and the students have with each other. One of the walls displays letters that the students have written to each other: "You are really friendly and smart." "Thanks for being such a good friend."

"I BELIEVE THAT OUR CLASSROOM SHOULD BE A PLACE THAT IS NICER THAN THE REAL WORLD, WHERE KIDS FEEL ACCEPTED AND CARED FOR. IT GIVES THEM A CHANCE TO SEE HOW GOOD IT FEELS."

Although creating a positive classroom environment helps to improve learning and academic achievement, there are other important benefits. Redlinger's approach is centered on making the classroom a good place for students to be. "I believe that our classroom should be a place that is nicer than the real world, where kids feel accepted and cared for. It gives them a chance to see how good it feels."

Settling into the room on a sunny spring day, the sixth-grade students are talkative as they greet each other and the teacher. Redlinger moves about the room, speaking to students individually. Some of them are eager to share stories about what happened in the previous class or about missing the bus. Even as they chat, all of the students begin writing down the mathematics assignment from the board. They do this without a prompt from the teacher, and it seems like a familiar routine.

From the beginning of the school year, Redlinger collaborates with the students to shape the classroom environment. Students work together to define and establish the type of classroom that they need. "The students discuss what we need the classroom to be like in order to learn," says Redlinger. "Some kids like it very quiet, while others just go nuts if it is silent. So I ask

them to think about their own needs, as well as other students' needs. We talk about things like, 'Is it okay if everyone is running around?' and 'What about if people are talking?'" This discussion helps the students to focus on how they learn and helps them realize they can do things to help themselves learn.

As students finish writing down the assignment, Redlinger arranges them into groups of four. Some of the students negotiate a bit, requesting to be in certain groups. One boy seems reluctant to move his desk. When his classmates begin to protest, the teacher simply asks him, "Is that being a group member?" With a small grimace, he gets up to maneuver his chair and desk. This exchange is characteristic of Redlinger's relationship with her students. She is firm, but she is more likely to ask a question than issue an order.

Redlinger has asked students to explain how two equations represent two variations of a shape. She moves throughout the room, listening and watching the group discussions. She also encourages the students as they work, telling them, "You guys are asking good questions. Talk about it at your table."

After they have worked for a short time, some of the students begin to complain that the assignment is difficult. Redlinger tells them, "Just keep talking about it in your groups. Come up with some observations and questions." She also encourages them to collaborate between their groups: "Remember, if you get stuck, you can go talk to another group to see what they are doing." When they work in groups, Redlinger's students are free to move around the room and go to other tables for help. She encourages students to share their learning rather than compete with each other for points or grades.

Eventually, Redlinger asks each group to choose a representative to meet with her at the front of the room if they are stuck or uncertain. The rest of the students continue to work in their groups. While she does provide guidance, the focus is on the students helping each other as they discuss what their groups have done so far. The representatives then return to their tables to explain what they discovered.

After all the groups have come up with their answers, they share their explanations of the equations and the methods that they used to come up with them. Redlinger moves to the back of the room as the students present. She asks occasional questions, but gives the students the floor. Each group has slightly different ideas to contribute. One student asks a question about a group's explanation:

"You guys used the number two in the problem, but could it be any number?"

"It could be any number. We just used two as an example," the presenter replies.

"It is really important to let the kids do most of the talking," Redlinger explains. "They should be the ones who ask each other questions and correct each others' mistakes. I try to stay neutral so that students have opportunities to share their ideas. For example, when students make a mistake or have a

flaw in their reasoning, I don't immediately get involved and correct them. First, I wait to see if the other students catch it. Only if they fail to see it do I jump in and try to help them see their mistake."

Making this kind of communication possible is an ongoing process of building and maintaining relationships. When she talks about her classroom, Redlinger emphasizes the importance of connection and rapport. "I find that it is really important to know all of my kids, and to accept them for who they are. Kids have to feel like you care about them." Equally important are students' relationships with each other, which are also an ongoing concern. Watching this group of students at the end of the school year provides evidence of both problems and successes.

In the second activity of the day, the students are creating definitions of all four arithmetic operations. Redlinger asks them to come up with different ways of describing addition, subtraction, multiplication, and division. After the class has been discussing their ideas in groups for several minutes, Robert calls out to the teacher. He is impressed with the explanation that Sean, a fellow group member, has given, and he wants to make sure that Redlinger and the whole class hears it.

"Wow! Did you hear what Sean said?"

"No, what did he say? Go ahead, Sean," says Redlinger.

"Five is the difference between six and 11."

"Yes, exactly. That's a great way of saying it."

It is often unusual to see students show such excitement about their classmates' learning. Robert's efforts on behalf of Sean—as well as the way that students interact with each other throughout the day—demonstrate students' positive relationships with each other. Redlinger's modeling and attention make these relationships possible, and there are sometimes conflicts to resolve.

During the class, Brian approaches Redlinger in order to talk about a problem that he is having with a member of his group. "We just don't like each other .... No offense, Mary." The girl named Mary agrees with him.

"Let's talk about this after class. We need to discuss the problem," Redlinger replies.

"Can't you just move us to other seats?"

"No, I think all three of us need to talk about this."

After class, Redlinger explains her concerns to the two students. "When the two of you say that you just don't like each other—even when you say 'No offense' like Brian did—it sounds like you are really saying that you think the other person is not good enough to be in your group. That's why I think it's important to work this out. I would like it if you guys can get along. What do you think we should do about this?" After explaining her own rationale, Redlinger leaves the decision up to the students. She believes that it is im-

portant to let students practice making choices, and this approach to resolving the conflict proves to be effective, perhaps even more effective than coercion or punishment. Brian and Mary decide to attempt to resolve their differences. If that does not work, one of them will switch seats so that they will still be in the same group, but they will not be sitting directly together.

A conflict also comes up in a different group. Mark is not participating and is distracting the other students with a bug. Redlinger brings over Paul, who has come in late from a dentist appointment. She asks Mark to explain what they are working on to his classmate. "I want you to explain it to Paul. I'll come back and ask him a question, so I'll see if you have done a good job." Given a new task, Mark seems to take his job seriously. Redlinger returns several times, asking Paul a question and telling Mark, "Okay, now teach him something else, and I'll come back." As the groups are finishing up, she comes back for a final question. After she hears Paul's answer she says to Mark, "You both did a good job."

"I'm a good teacher!" says Mark.

"Yes, you are!" Redlinger replies, giving him a high-five.

Creating Collaborative Learning Contexts

A LEARNING COMMUNITY IS DISTINGUISHED BY AN EMPHASIS on collaboration. Students do not construct knowledge in isolation, but through social interaction with their peers. This means that processes that enable students to create ideas and negotiate meaning together are essential. Students also take responsibility for each other's learning, sharing their own discoveries and understandings by teaching each other.

Students who have opportunities to collaborate in mathematics and science generate a wider variety of strategies, have opportunities to share information and ideas, and can develop a shared understanding of the topics they are learning. A long history of research on cooperative groups in mathematics shows that student teams consistently outperform individuals in problem solving (Qin, Johnson, & Johnson, 1995). Clearly, social interaction and collaboration are essential to learning.

Nevertheless, partnerships and teams must be carefully established and facilitated in order to be effective. Collaboration is an important skill and must be one of the goals of learning rather than just a means of completing work or a fun alternative to individual assignments (Johnson, Johnson, & Holubec, 1994). Two important areas must be addressed in order to establish collaboration: group process skills and status.

Group process skills. Students must learn the skills of working together, which will not happen automatically. When problems arise, teachers may be tempted to cut activities short or disband learning groups. However, solving problems related to working together is an important skill for students to learn. This means taking the time to help students find strategies to resolve their difficulties and to take responsibility for helping each other (Parker, 1993).

Teachers sometimes initiate a discussion about the process of collaboration with students before they begin an activity. One of the goals is to ensure that students understand that they are accountable for their own and each group member's learning. The teacher also guides students in establishing some guidelines for working together.

A similar approach is to encourage students to discuss and reflect on how they work together after they have completed an activity. Students may find it easier to establish guidelines and norms for collaboration when they reflect on a recent experience. Students will identify what they did well and what they need to improve, with reminders to refrain from blaming each other. In the beginning of the year, teachers may want to begin with shorter and less complex tasks so that there is time for discussions about the process of collaboration (Tsurda, 1994). Teachers will find helpful guidelines for debriefing group process skills in two books by Johnson, Johnson, and Holubec, *New Circles of Learning: Cooperation in the Classroom and School* (1994), and *Cooperation in the Classroom* (1998). (See the Resources section at the end of this publication for more information.)

Other strategies for facilitating group work vary, and their effectiveness will depend on the goals of the teacher and on the students. Some teachers give students permanent or semipermanent group assignments, so that the group members can establish a better working relationship over time. Other teachers feel that it is important for students to work in different groups, so that they have opportunities to interact with all of their classmates. Teachers may also find it helpful to assign students roles in each group—such as timekeeper, recorder, and reporter—in order to ensure equal participation. However, students also benefit from the process of negotiating their roles and building on each other's strengths within their groups.

Students can be members of many groups at once. They may be paired with "buddies" of their own choosing throughout the school year, with the two students sharing responsibility for helping each other with a variety of tasks. Seat assignments can often determine partners for a day or for the duration of a single problem. Labs and activities may have three or four members working together for a few weeks.

Status. The benefits of collaboration are often undermined by unequal participation. The most frequent source of unequal participation is unequal status among students. There are a number of sources of status, including achievement, popularity, class, ethnicity, and gender. High-status students tend to be more active than low-status students, which often means that low-status students learn less than their peers (Cohen, 1998).

There are two strategies that help to eliminate stratification in groups, as well as in the classroom. One is designing and selecting tasks that require multiple abilities and then discussing the skills that the task will require before students begin work. In the discussion, the teacher emphasizes that not everyone will have all of the necessary skills, but that all students will have some of them (Cohen & Lotan, 1995). Groups will be successful as long as all of the members contribute their abilities. The teacher can also point out that this is an opportunity for students to learn from each other's strengths.

This is similar to the concept of "distributed expertise" in the Fostering a Community of Learners model developed by Brown and Campione (1994). The model is based on extended investigations in areas such as biology and ecology. Groups of students work on various subtopics that relate to the main topic that the whole class is studying. Rather than all students pursuing the same tasks and gathering the same information, students are responsible for becoming experts and teaching their classmates what they have learned. Students draw on their interests and strengths to contribute to the knowledge of the whole class (Brown & Campione, 1994).

A second strategy for addressing problems of status is assigning competence. As the students work, the teacher finds opportunities to point out the strengths of a low-status student. These affirmations must be genuine as well as public, so that the group or the whole class can see the student through this lens. Teachers who draw on these two strategies with frequency show a significant and positive effect on the participation of low-status students and reduce status problems at the classroom level (Cohen & Lotan, 1995).

Sharing Authority and Control

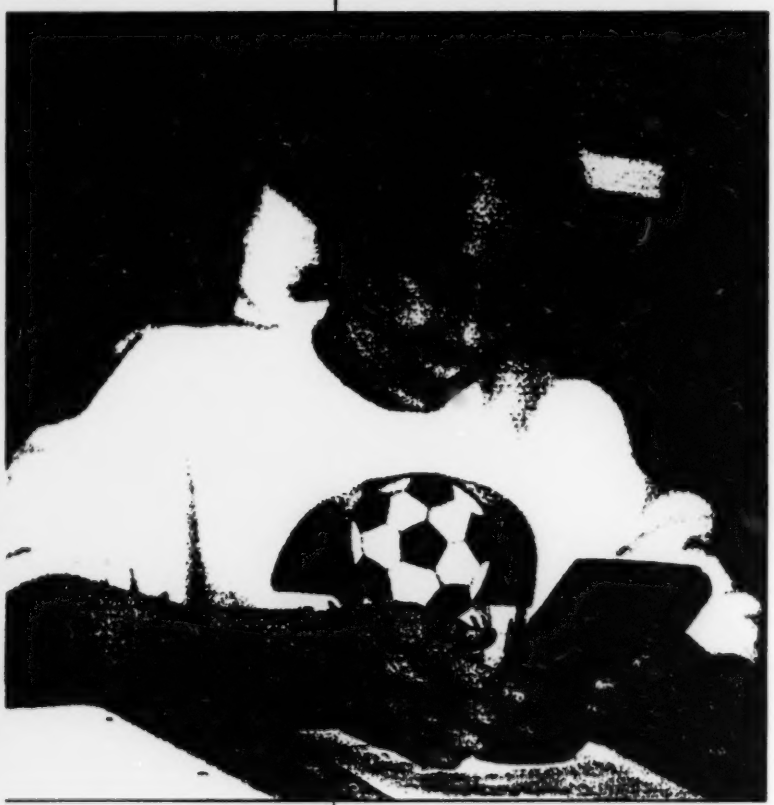
IN A LEARNING COMMUNITY, AUTHORITY DOES NOT RESIDE exclusively with the teacher. While the teacher necessarily has more authority than the students do, she does not use her position to control students. Instead, she helps empower students to make good decisions and to take an active role in their own learning and the classroom (Peterson, 1992).

Many teachers worry that allowing students to take on new roles and responsibilities means that they will not be able to control the classroom. This is not the purpose or the outcome of encouraging students to take more active roles. Rather than giving up order and discipline or giving students "free rein," the teacher empowers students to *participate* in making decisions about their behavior. In fact, successful teachers in diverse cultural settings report that they share their authority with their students. They also gain their authority from a variety of sources—such as knowledge of their students, caring, and creating a safe and respectful environment—rather than just from their position as the teacher (Rose, 1995).

Is it possible for teachers to control learning? While teachers can influence the process, ultimately students themselves determine what and when they learn. Whether or not teachers are successful in helping students to learn depends on their abilities to establish supportive relationships with students and to engage them in meaningful and worthwhile activities (McCombs & Whisler, 1997). Giving students control over their learning increases motivation, promotes understanding and engagement, and reduces discipline problems (Ridley, McCombs, & Taylor, 1994).

Students are often not aware of the control that they have over their own learning, even though this is an important skill. Because students are usually accustomed to being passive in school, they will need to ease into this role. Students often have little experience in making choices and decisions. In fact, it is not uncommon for discipline problems to initially increase when students have opportunities for more control (Ridley, McCombs, & Taylor, 1994). The teacher can prevent this by being explicit about the roles that she is encouraging students to take on and discussing new responsibilities and expectations.

Another aspect of authority in the classroom is the source of validation for ideas and solutions. In a learning community, the whole class is responsible for making sense of mathematics and science. The students work with each other and the teacher to test and validate their ideas and methods rather than looking to the teacher as the sole voice of authority. All students help to designate the criteria for valid solutions and acceptable explanations, guiding the development of a "community of validators" (Yackel & Cobb, 1996).



Teachers often find it difficult to share authority with students. Teachers are accustomed to being the source of information and to controlling all aspects of classroom activity as well as the flow of talk. Making changes takes time as well as a commitment to trial and error. Teachers will still create the overall structure of the classroom, but it will be designed to give students more freedom within that structure. This is an ongoing and complex process that cannot be prescribed.

Promoting Active Participation

ONE OF THE PURPOSES OF THE LEARNING COMMUNITY IS TO ensure that students are active participants in the classroom. Active engagement is important for encouraging motivation and a key factor in learning. The extent to which students actively participate in classroom activities and discussions also has a significant impact on their perceptions of the learning environment.

A classroom community in which students are active members is important not only because of positive student outcomes. It also plays a part in modeling the nature of inquiry and problem solving—the processes of doing mathematics and science (Huffman, Lawrenz, & Minger, 1997). Personal involvement and learning are enhanced with opportunities to figure things out, to interpret the results of investigations, to generate hypotheses, and to create knowledge and meaning (Roth & Roychoudhury, 1994). Active participation is a necessity rather than an option or an enhancement. Students learn by doing mathematics and science and making sense of what they are studying rather than listening to lectures and following prescribed procedures.

There are a variety of ways for students to be actively involved in the classroom. Whenever possible, students should have a voice in setting goals, planning activities, assessing their work, and designing the physical space in which they work (NRC, 1996). The sense of community in the classroom and student learning overall is enhanced when students are free to move about the classroom, to observe each other at work, and to talk to each other about their ideas (Roth, 1995).

Choice. Learning mathematics and science means learning how to choose methods for solving problems and conducting investigations. Without opportunities to make choices, students will be missing a vital piece of their education. While teachers guide the overall organization of the curriculum and activities, they also create a framework in which students can make choices and decisions.

There are a number of ways to provide opportunities for students to make choices. Students can choose topics and activities that they are interested

in, as well as ways to assess and demonstrate their learning. Asking students to pose questions focuses learning on topics and ideas that they are curious about and often enriches the mathematics and science that they are required to learn.

Ensuring that students have opportunities to make choices does not mean that students participate only in activities of their choosing or only put in as much effort as they wish. It is possible for teachers to create a system for holding students accountable for their work while at the same time giving them freedom to pursue their interests. For example, in a science class in which the students spend most of their time on independent investigations, the teacher can use a daily "status of the class" conference to monitor students' progress (Ivy, 1994). In a five-minute meeting at the beginning of each class, the students give quick reports about what they are working on and their next steps. The teacher has individual conferences with students if they appear to be making little progress in order to find out what is holding them back (Ivy, 1994).

New roles. In order to construct their own knowledge and develop understanding, students need to take on new roles in the classroom. For example, students need opportunities to pose questions about mathematics and science, as well as to set their own learning goals. All members have a variety of responsibilities in the context of a learning community. Some roles that students will take on include:

- **Teaching** other students, perhaps even designing and facilitating activities for their peers
- **Presenting and defending** their ideas, solutions, and findings
- **Questioning** each other's strategies and understanding
- **Assessing** their own and other students' reasoning

"CONSTRUCTIVIST TEACHERS VIEW THEMSELVES AS GARDENERS, TOUR GUIDES, LEARNING COUNSELORS, OR FACILITATORS RATHER THAN AS DISPENSERS OF INFORMATION OR JUDGES OF RIGHT AND WRONG ANSWERS."

(Roth & Roychoudhury, 1994)

Teachers also take on new roles as students become more active. They are often co-learners with their students. Rather than presenting students with information and procedures, they are appreciative and investigative audiences for students' ideas. In discussions, teachers give the students opportunities to talk to each other and to ask each other questions rather than controlling the flow of conversation.

Meaningful Context. Students are most engaged when they see that the science and mathematics they are learning is relevant, challenging, useful, and interesting. Teachers can encourage student motivation and engagement by helping them to make these connections. This includes matching tasks and themes to students and the ways that they best make sense of what they are learning (Lappan & Ferrini-Mundy, 1993). Teachers

do this by connecting new ideas to students' prior learning, observing and talking to their students, and drawing on the general knowledge base about how students learn mathematics and science.

Intrinsic motivation is associated with activities that are inherently enjoyable, interesting, or challenging. "It seems reasonable to assume that intrinsic motivation can only be maintained as long as learning activities lead to a certain level of positive emotional experience" (Schiefele & Csikszentmihalyi, 1995). While this does not mean that *all* mathematics and science activities must be fun, interesting and challenging questions and problems are essential. Students learn more when teachers make mathematics and science problematic. This means that instead of memorizing or practicing facts and procedures, students must devise and select their own methods for solving a problem or answering a question (Hiebert et al., 1997). In addition, students are eager to be actively involved in tasks that help them solve problems from their own experiences or to answer their own questions. This helps to bring a sense of shared purpose to learning and classroom activities.

Presenting mathematics and science knowledge as growing and changing, rather than fixed, helps bring the topics to life. Mathematics and science become more interesting and accessible because students gain an under-

standing that the ideas they are learning are open to questioning and testing (Nickson, 1992). Teachers might devote a discussion to questions that science has not been able to answer, such as "What happened to the dinosaurs?" or "What is the smallest subatomic particle?" (Hassard, 1990).

Another means of providing context is emphasizing and exploring the human purposes of mathematics and science. One way to do this is by including contemporary and historical mathematicians and scientists into the subjects that students are learning. Guest speakers from the community provide role models and connect students to real people who do mathematics and science. It may require a bit of extra time to ensure that students learn about women and people of color, because their contributions are often left out of resources on the history of mathematics and science. (There are a number of materials available through NWREL's Mathematics and Science Education Center lending library—see the inside front cover of this publication for more information.)

"CLASSROOMS SHOULD BE PLACES IN WHICH STUDENTS CAN LEGITIMATELY ACT ON A RICH VARIETY OF PURPOSES, IN WHICH WONDER AND CURIOSITY ARE ALIVE, IN WHICH STUDENTS AND TEACHERS LIVE TOGETHER AND GROW."

(Noddings, 1992)

Weaving discussion or written assignments about ethics into mathematics and science also helps to provide a human context (Hassard, 1990). Possible topics include cloning and genetic engineering, environmental destruction, and the manipulation of statistics. Students and teachers might also explore the potential of science and mathematics to help people and to address social problems.

Ensuring Intellectual Rigor

SOMETIMES TEACHERS MISCONSTRUE THE CHARGE TO CREATE a supportive classroom climate to mean that students should not be challenged. They may be tempted to make tasks easier for students or to praise them for minimal effort and for meeting general expectations. Unfortunately, such attempts actually accomplish the opposite of what teachers are trying to achieve. Students know false praise when they hear it, and it undermines their motivation to learn.

High expectations are an important part of creating a congenial learning environment. The teacher's expectations influence students' beliefs about their own abilities and roles in the classroom. Students learn and feel successful when they are challenged rather than when they are completing tasks that they already know how to do. Having high expectations and ensuring that students are challenged also require support. Students learn best and perceive the classroom favorably when there are clear expectations for their work. The benefits are even greater when students have a hand in setting the criteria by which they will be evaluated.

Mathematics and science standards—whether they come from professional organizations, state departments of education, or individual school districts—are an accessible tool for establishing expectations and providing support. The national mathematics and science standards present useful examples of challenging and rigorous content (NCTM, 1989; NRC, 1996). Sharing standards with students is also a means of providing them with clear guidelines for demonstrating and evaluating their learning.

Ongoing feedback is necessary in supporting high expectations and challenging activities. When students are working on complex tasks and when they are responsible for determining the methods they use, they may feel uncertain or anxious. While some amount of uncertainty is necessary, students also may need occasional reassurance. For example, teachers might want to let students know that they are on the right track. At other times, teachers can redirect or refocus students by asking questions. Helping students to discover their own mistakes is much more effective than simply telling them what they have done wrong or the pieces they are missing.

Engaging in Reflection and Collaboration

TRANSFORMING THE CLASSROOM INTO A COMMUNITY OF learners can be a difficult change for teachers. It requires unlearning many deep-seated expectations about what classrooms should be like and what teachers and students should do. Such changes take time, patience, and perseverance.

In fact, a learning community is always in the making. Maintaining the sense of community will frequently involve unforeseen issues and complications. Every year will bring new students with new opportunities and challenges. As a result, an ongoing cycle of reflection, variation, and adjustment is key. The questions in the sidebar provide teachers with some issues to think about as they create and maintain the classroom community.

Because of the challenging nature of teaching in a learning community, teachers are encouraged to establish collaborative relationships with their colleagues. Just as respect, support, and interaction are necessary for students' learning, they are also essential for teachers. Following the model developed by Senge (1990), many business leaders are attempting to create learning organizations in order to constantly improve their products and services. It would seem that schools and districts would be ideal places to establish such learning organizations.

Questions for Reflection

- What do I believe about learning mathematics and science?
- What questions do I have about how students learn best? How can I find out?
- How can I get to know my students?
- What is my role as a teacher and as a member of the learning community?
- What roles do students play?
- What would a learning community be like in my classroom?
- What can I do to make the classroom a comfortable and caring place?

(Bridges, 1995)

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There are a number of strategies that help to establish a professional learning community within a school. Teachers can partner with a colleague who is interested in trying and discussing new approaches, providing mutual feedback and support. The whole staff might select a common question or issue on which to concentrate for the school year. Study groups provide opportunities for a group of teachers to learn together, share their frustrations, and talk openly about their teaching.

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Conclusion

THE QUALITIES OF A LEARNING COMMUNITY OUTLINED IN this publication are summarized in the table below. While the stories and strategies in this publication provide some guiding principles, they will look different in each classroom. The examples were selected to provide places to begin as well as ideas for improvement. Above all, the suggestions for nurturing relationships or sharing authority with students should not be misinterpreted as mandates for teachers to change their personalities. Instead, teachers will shape the classroom community with their students in order to promote the intellectual growth and well-being of all members. The following pages include resources that teachers may find helpful in creating and sustaining a learning community.

Traditional Classrooms	Learning Communities
■ Teacher does most of the talking	■ Students do most of the talking
■ Students work individually and compete with each other for points and grades	■ Students help each other, share ideas, and build on the thinking of others
■ Teacher establishes and enforces classroom rules and expectations	■ Students help to create and maintain rules
■ Teacher demonstrates procedures, and students follow directions	■ Students choose methods and develop their own procedures
■ Teacher is the authority and judge of correct methods and answers	■ Students and teacher establish validity through reason and evidence

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Resources and Bibliography

Resources for Further Reading

Adams, D., & Hamm, M. (1998). *Collaborative inquiry in science, math, and technology.* Portsmouth, NH: Heinemann.

This book shows elementary teachers how to integrate math, science, and technology in a cooperative learning environment. It offers a vision of classrooms in which students are encouraged to work together to construct meaning supported throughout by numerous inquiry-based, thematic activities specifically designed to promote reflective thinking.

Apple, M.W., & Beane, J.A. (Eds.) (1995). *Democratic schools.* Alexandria, VA: Association for Supervision and Curriculum Development.

In four narratives, educators describe how they initiated democratic practices in their educational settings. Acting as models of democratic principles in action, students in these schools learn through shared interests, freedom in interaction, participation, and social relationships.

Bridges, L. (1995). *Creating your classroom community.* York, ME: Stenhouse; & Los Angeles, CA: Galef Institute.

This book helps elementary school teachers create classrooms that support what we know about learning. Suggested practices, guiding questions, and classroom examples demonstrate how to organize the classroom to best support learning and how to help students develop and practice self-responsibility.

Duckworth, E. (1996). *"The having of wonderful ideas" and other essays on teaching and learning* (2nd ed.). New York, NY: Teachers College Press.

The essays in this book demonstrate how aspects of teaching must seek out, acknowledge, and take advantage of all the pathways that people might take to their understanding. Part of the work described in this book involves giving students an appreciation of their own and other people's ways of understanding.

Gibbs, J., and others (1994). *Tribes: A new way of learning together.* Santa Rosa, CA: Center Source.

Blending a number of educational fields, this book describes the ongoing development of the Tribes group process, whereby small learning groups are used to promote human growth and learning. Students learn to use specific collaborative skills, and to reflect on both the interaction and the learning that is taking place. The guide includes strategies, resources, and activities for designing and implementing learning experiences and for implementing the project.

Hiebert, J., Carpenter, T.P., Fennema, E., Fuson, K.C., Wearne, D., Murray, H., Olivier, A., Human, P. (1997). *Making sense: Teaching and learning mathematics with understanding.* Portsmouth, NH: Heinemann.

This book presents current research-based ideas on how to design classrooms that help students learn mathematics with understanding. By describing the essential features of classrooms that support students' mathematical understanding and by offering pictures of several classrooms that exhibit these features, the authors create a valuable framework within which teachers can reflect on their own practice and think again about what it means to teach for understanding.

Hassard, J. (1990). *Science experiences: Cooperative learning and the teaching of science.* Menlo Park, CA: Addison-Wesley.

This resource is designed to help elementary and middle school teachers create environments that provide experiential learning activities for students and to reorganize their classrooms into cooperative groups. The text includes both a discussion of the theory of science teaching and cooperative learning and eight science units with core activities, interdisciplinary activities, and projects.

Jensen, E. (1998). *Teaching with the brain in mind.* Alexandria, VA: Association of Supervision and Curriculum Development.

Brain-compatible teaching and learning are explored in this book, which reviews recent research and theory on the brain and balances this information with tips and techniques for using the information in classrooms.

Johnson, D.W., Johnson, R.T., & Holubec, E.J. (1998). *Cooperation in the classroom* (Revised ed.). Edina, MN: Interactive Book.

This book helps educators understand and implement cooperative learning. It outlines five essential components that make cooperation work and includes structures and plans for cooperative learning.

Johnson, D.W., Johnson, R.T., & Holubec, E. J.(1994). *New circles of learning: Cooperation in the classroom and school.* Alexandria, VA: Association for Supervision and Curriculum Development.

This resource includes many of the ideas from the book listed above, but in a shorter format.

Marlowe, B.A., & Page, M.L. (1998). *Creating and sustaining the constructivist classroom.* Thousand Oaks, CA: Corwin Press.

This book addresses key issues and provides practical tips, techniques, and examples to allow step-by-step implementation of constructivism. The book addresses all grade levels and includes examples from various teachers' experiences. Questions and checklists throughout the book provide teachers with tools for investigating their own teaching and classrooms, as well as opportunities for self-assessment and reflection.

McCombs, B.L., & Whisler, J.S. (1997). *The learner-centered classroom and school: Strategies for increasing student motivation and achievement.* San Francisco, CA: Jossey-Bass.

The learner-centered perspective begins with a focus on knowing and understanding each learner in the context of a deep understanding of the learning process itself. This volume reviews a number of approaches to the learner-centered classroom and synthesizes a focus on knowing and respecting individual learners with the best available research and practitioner experience about learning.

Palmer, P. J. (1998). *The courage to teach: Exploring the inner landscape of a teacher's life.* San Francisco, CA: Jossey-Bass.

This publication examines how teachers' inner lives shape teaching and learning both positively and negatively. It guides teachers through the process of self-appraisal with the goal of recovering passion for teaching, connecting with students, and creating communities of learning.

Peterson, R. (1992). *Life in a crowded place: Making a learning community* Portsmouth, NH: Heinemann.

This book explores how learning communities are created, helping teachers to understand the kind of community they are making (or need to make) and how that community functions to influence the quality of learning and life in elementary and middle school. Teachers will find examples of ways they can work with their students to initiate teaching and learning that is centered in critique and dialogue and gain an understanding of the importance of the social interaction in learning.

Reddy, M., Jacobs, P., McCrohon, C. & Herrenkohl, L.R. (1998). *Creating scientific communities in the elementary classroom.* Portsmouth, NH: Heinemann.

Based on transcripts of classroom conversations and samples of children's writing, this book looks at the social context of the classroom and its impact on science teaching and learning. The text features a variety of discourse strategies teachers can use to support, extend, and ultimately assess their students' understanding.

Ricks, J.J., & Collar, C.L. (1993). *"One of us is not as powerful as all of us": Building a community for teaching and learning mathematics.* East Lansing, MI: Michigan State University, Institute for Research on Teaching.

This report provides a snapshot of a fourth-grade classroom community focused on learning and understanding fractions. The authors explore the issues of intellectual risk taking, appreciation for diversity, trust, and shared ownership.

Organizations

Coalition of Essential Schools—CES National
1814 Franklin St., Suite 700
Oakland, CA 94612
Phone: (510) 433-1451
Fax: (510) 433-1455
Web: www.essentialschools.org/

The Coalition of Essential Schools (CES) is a grassroots school reform network of nearly 1,000 schools and 24 regional centers around the country and abroad. The program is designed to increase student achievement by rethinking priorities and redesigning curriculum, instruction, and assessment. The principles of CES promote opportunities for students to be active learners and changes in school schedules and routines that help teachers and students to know each other well and to work in an atmosphere of mutual trust and high expectations.

Developmental Studies Center
2000 Embarcadero, Suite 305
Oakland, CA 94606-5300
Phone: (510) 533-0213
Fax: (510) 464-3670
General e-mail: info@devstu.org
Web: www.devstu.org/

The Developmental Studies Center (DSC), formed in 1980, is dedicated to helping children develop intellectually, ethically, and socially. The program helps to develop school-based programs in the areas of literacy, numeracy, family involvement, and the building of a caring community in the classroom and school.

Northwest Regional Educational Laboratory (NWREL)
School Improvement Program
101 SW Main Street, Suite 500
Portland, OR 97204-3297
Phone: (503) 275-9500
Web: www.nwrel.org/ scpd/index.html

The School Improvement Program's Curriculum and Instruction Services has developed institutes and workshops to support schools and districts embarking on comprehensive efforts to renew curriculum and instruction. The Curriculum Inquiry Cycle, which includes a focus on Creating Optimal Learning Environments, is designed to engage teams of teachers or whole staffs in self-sustaining processes for improving curriculum and instruction. Assistance is available on a variety of topics within and across disciplines and grade levels.

Online Resources

Collaborative Lesson Archive
faldo.atmos.uiuc.edu/CLA/

This site is a forum for the creation, distribution, and archival of educational curricula for all grade levels and subject areas. All lessons are contributed by teachers.

Eisenhower National Clearinghouse for Mathematics and Science Education
www.enc.org/fr_index.htm

The site features a searchable database of print, video, and Internet resources.

Engines for Education
www.ils.nwu.edu/~e_for_e/nodes/I-M-NODE-4121-pg.html

An online "book" devoted to creating exciting learning environments where children learn by doing, especially through the use of technology. The site was developed by the Institute for the Learning Sciences at Northwestern University.

Learning Research and Development Center
www.lrdc.pitt.edu/default.htm

LRDC is a multidisciplinary research center whose mission is to understand and improve learning by children and adults in the organizational settings in which they live and work: schools, museums and other informal learning environments, and workplaces.

Pathways to School Improvement
www.ncrel.org/sdrs/

The North Central Regional Educational Laboratory's Web site provides practical, action-oriented summaries of best practices, research, school examples, and materials. See the Learning section for issues related to classroom environment.

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